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DIFFERENTIAL SUSCEPTIBILITY OF 19 WHITE PINE
SPECIES TO WOOLLY APHID (*PINEUS COLORADENSIS*)

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ABSTRACT

Several species of white pine appeared to be completely resistant to woolly aphid; others were highly susceptible. The level of infestation tended to be highest for species in subsection Strobi, for species from the North American Continent, and for species that are most susceptible to white pine blister rust.

KEYWORDS: White pine, woolly aphid, *Pineus coloradensis*, resistance to insects

Woolly aphids are common pests on conifers. Some like the balsam woolly aphid (*Adelges piceae*) on the true firs are very destructive (U.S. Department of Agriculture 1972; Page 1975). Several other species of the genus *Adelges* and the closely related genus *Pineus* can also at times cause severe damage and even mortality (U.S. Department of Agriculture 1972; Canadian Forestry Service 1965-1974).

Two common species of woolly aphids on white pines native to North America are *Pineus pinifoliae* and *P. coloradensis*. These species are usually minor pests in natural stands. However, in greenhouses and lathhouses these woolly aphids are a constant threat to the health and vigor of white pine seedlings. Normally when a few aphids are seen, measures are taken to quickly stop the infestation with an appropriate insecticide. Nevertheless, an epidemic of the woolly aphid, *P. coloradensis* (identified by L. M. Russell, U.S. National Museum), occurred in an experiment designed to evaluate the resistance of 19 species of white pine to blister rust. Differential susceptibility of some of these species to the infestation appeared to exist. While design circumstances discouraged statistical evaluation of susceptibility, the results were so strongly displayed as to suggest hypotheses of potential research interest to geneticists and entomologists.

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MATERIALS AND METHODS

Seedlings of 19 species (table 1) of white pine were grown in 2- by 2-inch pots. Fifty seedlings of each species were grown together as a plot. There were one to eight plots per block, and there were four blocks. Positions of the plots were randomized within each block (fig. 1).

The seedlings were maintained in a dormant condition in a greenhouse from October to May and in a lathhouse during the growing season. The seedlings became infested with the woolly aphid during July of the third growing season. At that time, the level of infestation of each plot was numerically rated.

Table 1.--Observed level of infestation of white pines infested with woolly aphid and the degree of resistance to white pine blister rust

Subsection and species	Continent	Blocks				Number of seedlings per species
		1	2	3	4	
- - Levels of infestation per plot ¹ - -						
SUBSECTION CEMBRAE						
<i>Pinus albicaulis</i> (Whitebark pine)	N. Am.	1,1,1	0,1,1	1,1,1	1,1,1	217
<i>P. cembra</i> (Swiss stone pine)	Eur.	0,0,0	0,0,0	0,0,1	0,0,1	302
<i>P. koraiensis</i> (Korean pine)	Asia	0,0,1	0,0,0	0,0,1	0,0,1	441
<i>P. pumila</i> (Japanese stone pine)	Asia	2,0,0	0,0,0	0	0,0	15
<i>P. sibirica</i> (Siberian stone pine)	Asia	0,0,0	0,0,0	0,0,0	0,0,0	443
SUBSECTION STROBI						
<i>P. armandii</i> (Armand pine)	Asia	0	0	0	0	200
<i>P. ayacahuite</i> (Mexican white pine)	N. Am.	1,1	1,1	1,1	2,2	399
<i>P. chiapensis</i> (Southern white pine)	N. Am.	3,3	3	3	3	129
<i>P. flexilis</i> (Limber pine)	N. Am.	1,0	0,0	1,0	1,0	369
<i>P. lambertiana</i> (Sugar pine)	N. Am.	3,3	3,3	3,3	3,3	262

This aphid produces "woolly" masses on the foliage. We estimated the amount of woolly mass over an entire plot and tabulated the data as a percent of foliage infested. We assumed that the amount of woolly mass was proportional to the numbers of aphids present. The rating system adopted was: (0) no aphids on the plot; (1) light infestation--1 to 30 percent of the foliage of the plot was infested; (2) moderate infestation--31 to 70 percent of the foliage of the plot was infested; (3) heavy infestation over 71 percent of the foliage of the plot was infested. This system was sensitive to large observable differences among the species. The data are presented in tabular form, and an infestation map (fig. 1) is provided to show the extent of the infestation within the experiment area.

Table 1.--(con.)

Subsection and species	Continent	Blocks				Number of seedlings per species
		1	2	3	4	

- - Levels of infestation per plot¹ - -

SUBSECTION STROBI

<i>P. monticola</i> (Western white pine)	N. Am.	2,2,3,3, 2,1,2,2	3,3,2,3, 2,1,3,3	1,1,1,3, 2,1,3,3	3,1,3,3, 3,2,3,3	1,502
<i>P. morrisonicola</i> (Taiwan white pine)	Asia	0,0	0	0	0	203
<i>P. parviflora</i> (Japanese white pine)	Asia	0,0,0	0,0,0	0,0,0	0,0,0	116
<i>P. peuce</i> (Balkan pine)	Eur.	2,2,1	1,2,0	1,1,1	1,2,0	374
<i>P. strobiformis</i> (Southwest white pine)	N. Am.	0,0	0,0	0,0	0,0	341
<i>P. strobus</i> (Eastern white pine)	N. Am.	2,2	2,2	3,1	2,2	397
<i>P. wallichiana</i> (Blue pine)	Asia	1,3	2,3	2,3	3,3	400

SUBSECTION BALFOURIANAE

<i>P. aristata</i> (Bristlecone pine)	N. Am.	1,2	2,1	1,1	2,1	102
<i>P. balfouriana</i> (Foxtail pine)	N. Am.	0,0	0,0	0,0	0,0	101

¹Ratings: 0 = no aphids; 1 = 1-30 percent of the foliage was infested; 2 = 31-70 percent of the foliage was infested; 3 = over 71 percent of the foliage was infested.

Legend:  no aphid infestation;  light infestation;  medium infestation;  heavy infestation.

Abbreviations: AL = *P. albicaulis*; AR = *P. armandii*; AS = *P. aristata*; AY = *P. ayacahuite*; BA = *P. balfouriana*; CE = *P. cembra*; CH = *P. chiapensis*; FL = *P. flexilis*; KO = *P. koraiensis*; LA = *P. lambertiana*; MN = *P. monticola*; MO = *P. morrisonicola*; PA = *P. parviflora*; PE = *P. peuce*; PU = *P. pumila*; SI = *P. sibirica*; STB = *P. strobiformis*; ST = *P. strobilus*; WA = *P. wallichiana*.

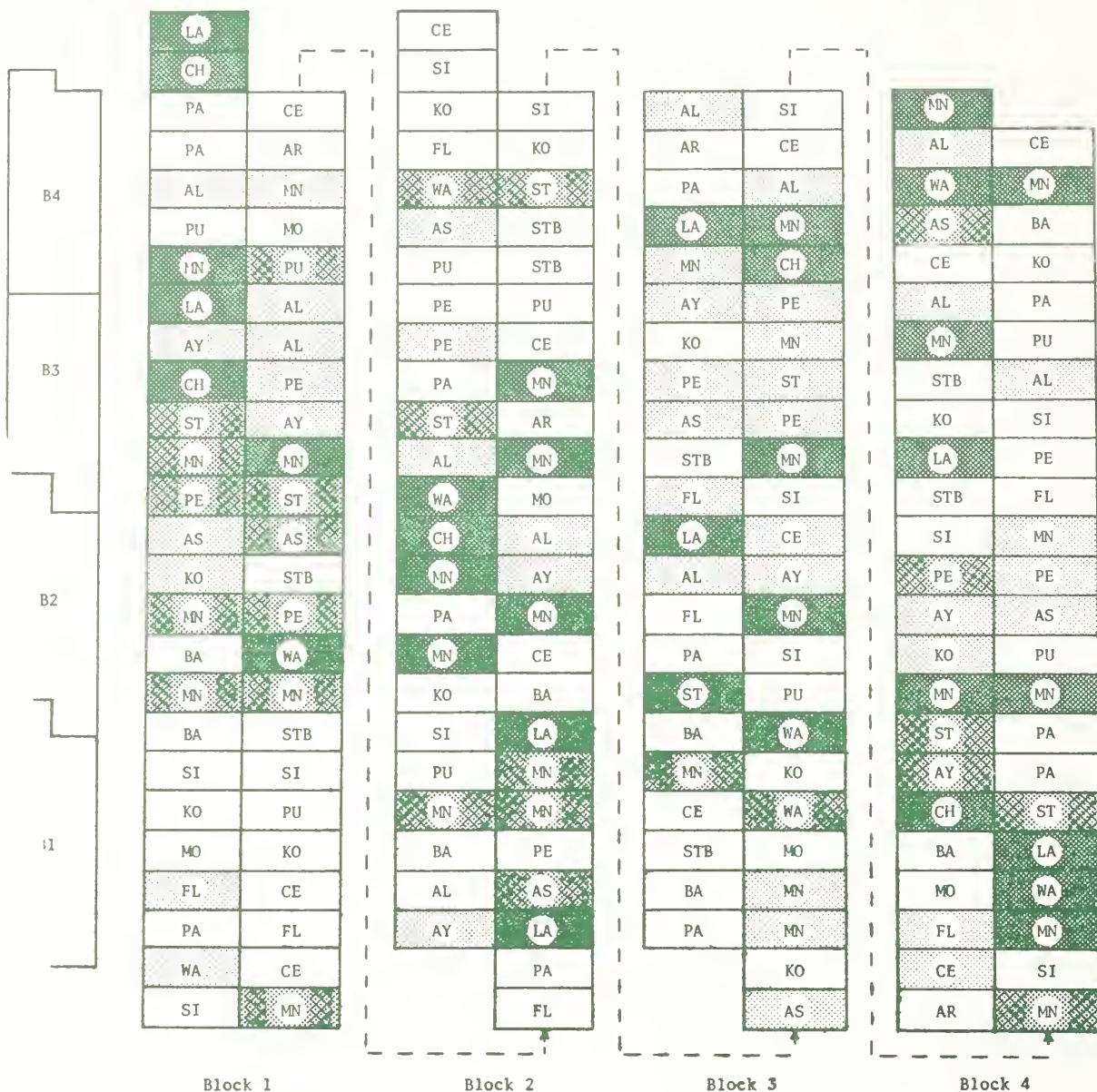


Figure 1.--Position of species plots within blocks and layout of blocks on lathhouse bench.

RESULTS AND DISCUSSION

The level of infestation of the various white pine species was strikingly different (table 1). Several species had little or no aphid infestation. Notable ones were *Pinus sibirica*, *P. armandii*, *P. morrisonicola*, *P. strobiformis*, and *P. balfouriana*, which had no infestation at all. Conversely, seedlings of *P. chiapensis*, *P. lambertiana*, *P. monticola*, *P. strobus*, and *P. wallichiana* were highly infested with aphids. The broad distribution of infested plots suggests that the entire experimental area was subjected to aphid attack. Frequently, seedlings of highly infested species grew side by side (with foliage intermingled) with completely uninfested seedlings of other species. For instance, no aphids were observed on any of the seedlings of *P. parviflora* (PA), yet 9 of the 12 plots were adjacent to species with high infestation. The aphid appears to be quite mobile and selective in picking a host. But some areas within the blocks had no aphid infestations. These could be groups of "resistant" species or escapes.

The white pines are a closely related group of species, many of which can be crossed with full fertility (Bingham 1972). Many of the species separations are arbitrary, based mainly upon geographical separation and relatively few morphological characteristics. But the separations are useful because they designate populations, some of which have been separated for millions of years.

Our interest in this group is to transfer genes that impart high resistance to white pine blister rust in species such as *Pinus armandii*, *P. wallichiana*, and *P. koraiensis* to species with high susceptibility such as *P. monticola*, *P. strobus*, and *P. lambertiana*. Knowledge concerning the presence and the levels of resistance in the white pine species has been a great aid in developing a hybridization program. Likewise, it is important to document patterns of adaptability of the same species to inland conditions to determine their potential for hybridization.

In the inland forests (eastern Washington, Idaho, and Montana), hybrids must be sufficiently cold resistant to survive temperatures as low as -40° to -50° F. Droughts also are frequent in these forests. Thirty years ago, "pole-blight" damaged and killed many individual western white pines. This disease is thought to be caused by drought (Leaphart, and others 1957). On the other hand, the last three summers (1974, 1975, and 1976) were abnormally wet with the result that infection levels, and even mortality due to at least one disease, needle blight (caused by *Lecanosticta* sp. and other associated insect and disease organisms), has increased. Therefore, the levels of resistance or susceptibility to many native pests and the factors that influence them in the species and hybrids in a hybridization program are also important criteria. For white pine, we hope to transfer some of the genes for resistance to blister rust--that we have not already found in the populations of the susceptible pines--from the resistant to the susceptible species. At the same time, we hope to produce a hybrid that is adaptable to the inland environment, including insects and disease pests.

The meaning of the patterns of variability in woolly aphid infestations is not immediately clear. Nonetheless, we feel the point is clear that knowledge about variability patterns in response to pests is as important to hybridization programs as knowledge about cold hardiness, drought hardiness, and other responses to the environment.

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